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NASA Technical Memorandum 105647

Nonplanar Linearly Tapered Slot Antenna With Balanced Microstrip Feed

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Prepared for the
IEEE-APS International Symposium
Chicago, Illinois, July 18-25, 1992

NASA

(NASA-TM-105647) NONPLANAR LINEARLY TAPERED SLOT ANTENNA WITH BALANCED MICROSTRIP FEED (NASA) 6 p CSCL 09C

N92-23535

Unclas

G3/33 0086828

E-6754

NONPLANAR LINEARLY TAPERED SLOT ANTENNA WITH BALANCED MICROSTRIP FEED

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ABSTRACT

A nonplanar linearly tapered slot antenna (LTSA) has been fabricated and tested at frequencies from 8 to 32 GHz. The LTSA is excited by a broadband balanced microstrip transformer. The measured results include the input return loss as well as the radiation pattern of the antenna.

INTRODUCTION

Linearly tapered slot antennas (LTSAs) have many salient features such as narrow beam width, high element gain, wide bandwidth and small transverse spacing between elements in an array. These features make them attractive in satellite communication antennas involving beam shaping and switching (ref. 1). Previously reported LTSA antennas are excited either by a fin line (ref. 2), coplanar waveguide (CPW) (ref. 3), or by a microstrip to slot line transition (ref. 3). The latter makes use of quarter wavelength stubs for impedance matching and hence the 2:1 VSWR bandwidth of the circuit is very small (ref. 3).

This paper describes the design and performance of a LTSA excited by a balanced microstrip (fig. 1). Compared to the fin line feed, the new design is smaller, less complex, and is not limited to a waveguide band. In addition, when compared to CPW or microstrip/slot line feed, the new design eliminates the necessity of quarter wavelength stubs and hence has a much wider bandwidth.

BALANCED MICROSTRIP FEED DESIGN

The feed system, as shown in figure 1, consists of a conventional microstrip on a dielectric substrate of thickness D with the ground plane tapered to a width equal to the strip width W (0.071 cm) to form a balanced microstrip. The radius R_2 of the arc is arbitrarily chosen as half free space wavelength ($\lambda_o/2$) at the design frequency (f_o) of 18 GHz. The taper helps to match the characteristic impedance of the conventional microstrip (50 Ω) to the balanced microstrip. The characteristic impedance of the balanced microstrip is chosen as $\approx$160 Ω which is equal to the input impedance of the LTSA. This input impedance is twice the input impedance of a regular half LTSA above a ground plane ($\approx$80 Ω) (ref. 2). The electric field lines at various cross sections along the feed and the antenna are shown in figure 2. The electric field lines which are spread out in the conventional microstrip concentrate between the metal strips of the balanced microstrip and finally rotate while travelling along the axis of the antenna.

NONPLANAR LTSA DESIGN

The nonplanar LTSA is formed by gradually flaring the strip conductors of the balanced microstrip on opposite sides of the dielectric substrate by an angle α with respect to the antenna axis. A symmetric beam width is necessary while illuminating a reflector for maximum aperture efficiency; this is achieved is 2α is close to 11° (ref. 1). Hence α is chosen as 5.3° in our design. The radius R_1 of the arc is arbitrarily chosen as 0.9 λ_o. In order for the LTSA to operate as a travelling wave antenna, the width H must be greater than $\lambda_o/2$ (ref. 1); hence, H is chosen as 0.75 λ_o. The length L of the antenna as determined by α and H is 4.3 λ_o. The entire circuit is fabricated on 0.0508 cm thick RT/Duroid 5880 ($\epsilon_r = 2.2$) substrate. This substrate has an effective thickness ratio of 0.03 which is within the optimum range for high gain and low side lobes (ref. 1).

ANTENNA PERFORMANCE AND DISCUSSIONS

The measured return loss (S_{11}) at the coaxial input port of the feed network is shown in figure 3. The return loss is observed to be better than -10 dB (2:1 VSWR) over a frequency range extending from 8 to 32 GHz. This is a significant improvement over the LTSA reported in the literature (ref. 3).

The measured E- and H-plane radiation patterns at three different frequencies are shown in figures 4(a) and (b) respectively. The measured patterns are found to be excellent.

The measured H-Plane cross-polarized radiation is -16 dB below the copolarized radiation at f_o. Further improvement could be achieved by varying the substrate thickness.

CONCLUSIONS

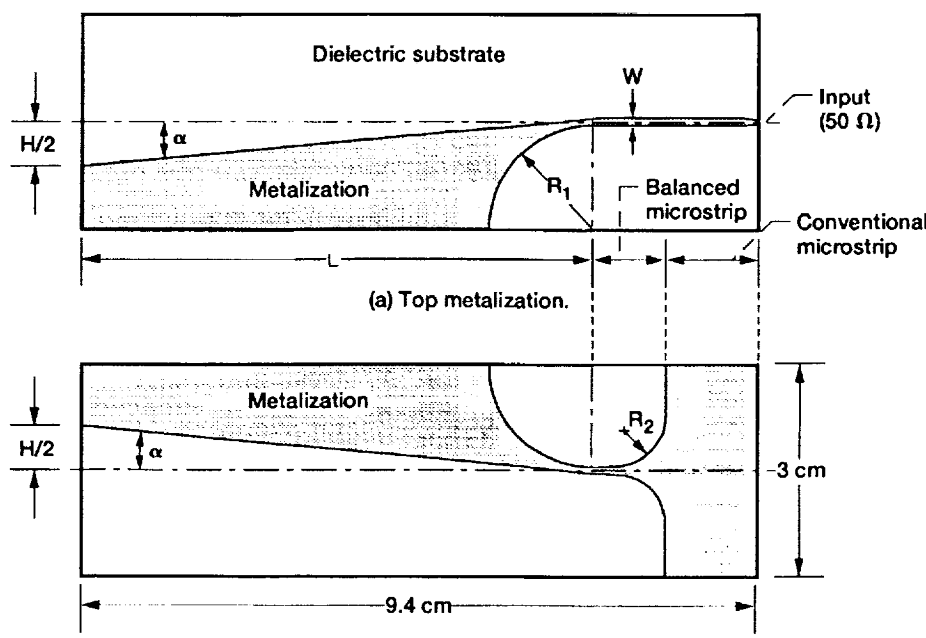
The design and performance characteristics of a LTSA with a balanced microstrip feed network has been presented. A LTSA fed with this feed network exhibits very broad bandwidth extending from X-band to Ka-band with good impedance match and excellent radiation patterns.

REFERENCES

1. Yngvesson, K.S., et al.: The Tapered Slot Antenna - A New Integrated Element for Millimeter-Wave Applications. IEEE Trans. Microwave Theory Tech., vol. MTT-37, no. 2, Feb. 1989, pp. 365-374.

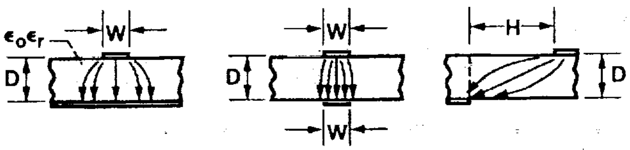
2. Yngvesson, K.S., et al.: Endfire Tapered Slot Antennas on Dielectric Substrates. IEEE Trans. Antennas Propag., vol. AP-33, no. 12, Dec. 1985, pp. 1392-1399.

3. Nesic, A.: Endfire Slot Line Antennas Excited by a Coplanar Waveguide. IEEE AP-S International Symposium Digest, IEEE, New York, 1991, pp. 700-702.



(b) Bottom metalization.

Figure 1.—Non-planar linearly tapered slot antenna and feed network.



(a) Conventional microstrip. (b) Balanced microstrip. (c) Antenna radiating edge.

Figure 2.—The electric field distribution at various cross sections.

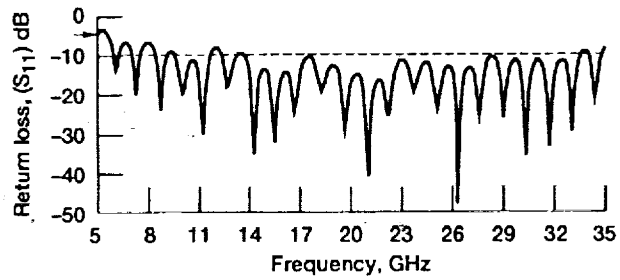


Figure 3.—Measured return loss (S_{11}) at the coaxial input port.

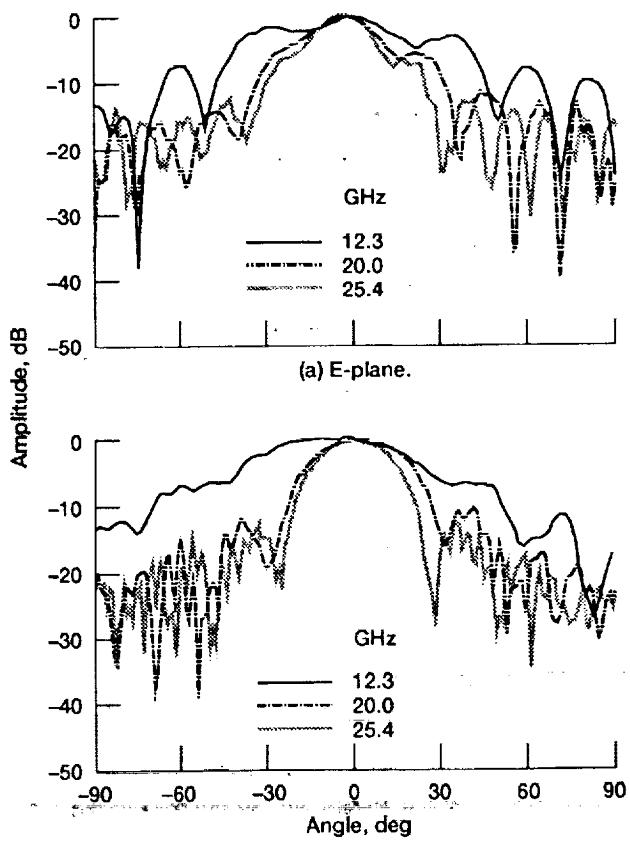


Figure 4.—Measured radiation pattern of the non-planar LTSA.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
1992

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Nonplanar Linearly Tapered Slot Antenna With Balanced Microstrip Feed

5. FUNDING NUMBERS
WU-506-44-2C

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
E-6754

9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, D.C. 20546-0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-105647

11. SUPPLEMENTARY NOTES
Prepared for the IEEE-APS International Symposium, Chicago, Illinois, July 18–25, 1992. Rainee N. Simons, Sverdrup Technology, Inc., Lewis Research Center Group, 2001 Aerospace Parkway, Brook Park, Ohio 44142 (work funded under NASA contract NAS3-25266); Richard Q. Lee, NASA Lewis Research Center; Thomas D. Perl, University of Akron, Akron, Ohio 44325. Responsible person, Rainee N. Simons, (216) 433-3462.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited
Subject Category 33

12b. DISTRIBUTION CODE

13. ABSTRACT ***(Maximum 200 words)***

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14. SUBJECT TERMS
Slot antennas; Microstrip feed; Microstrip antennas; Strip transmission lines

15. NUMBER OF PAGES
6

16. PRICE CODE
A02

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	